Volume II. *October, 1898.* *Number 2.*

ZOÖLOGICAL BULLETIN.

OBSERVATIONS ON THE ANATOMY OF A SPECIES OF PLATYASPIS FOUND PARASITIC ON THE UNIONIDAE OF LAKE CHAUTAUQUA.

HENRY LESLIE OSBORN.

THE facts recorded in this article were gathered partly on living material at Chautauqua, New York, in the Biological Laboratory of Chautauqua College of Liberal Arts, and chiefly in the Biological Laboratory of Hamline University, St. Paul, Minn. The fluke was first noticed in July, 1895, in specimens of Anodonta which were being used in class work. A few drawings were made at the time, but no attempt at identification could be undertaken then, as the necessary books were not at hand. Later in the year I consulted Bronn's *Klassen und Ordnungen* and decided that it could not possibly be regarded as the usual parasite of the *Unionidae Aspidogaster conchicola*, and recognized that it bore a remarkably close superficial resemblance to a species designated in that work as the *Aspidogaster lenoiri* of Poirier ('**85**). Such points as could be determined by a mere surface study of the animal indicated clearly a very decided likeness between Poirier's species and mine, but the point which made me hesitate in associating them at that time was the fact that Poirier's animal is only recorded from a single region, *viz.*, Senegal, Africa, and from a single host, *Tetrathyra vaillanti, a chelonian.* Unfamiliarity with the Trematoda and pressure of other work prevented me from investigating the case at that time, and I did not really take it in hand till the fall of 1897, when I was gathering the facts for a paper, Osborn ('**98**), on the dis-

coloration of Anodonta shells by a distomid parasite. I planned then to append the facts about Platyaspis to that paper in a short note. But as soon as I looked into the case I found a number of interesting points whose novel character made it necessary to present the evidences in the case in a way impossible in a mere note, and hence I withheld the matter and have made it the subject of another article. Poirier referred the animal which he discovered to the genus Aspidogaster, and Braun ('92) in Bronn's *Klassen und Ordnungen* followed his assignment of the animal to that genus. But Monticelli ('92), in his revision of the Aspidobothridae which accompanies the paper on *Cotylaspis* in Leukart's Festschrift, showed that Poirier's animal cannot be regarded as an *Aspidogaster*, and erected for it the genus *Platyaspis*, of which it has thus far been the solitary species. So far as I have been able to ascertain, Platyaspis has never been recognized, excepting from the one locality in which Poirier found and described it. It is, consequently, an interesting and remarkable fact that it should occur in this country and in a very different host, and a fact which should not be presented without a sufficiently detailed account of the evidence to compel belief in the correctness of the observation.

I have not been able to decide in my own mind whether the Chautauqua animal is specifically distinct from the African species or not. This is partly because I have not as yet had access to the original descriptions of Poirier, and do not know how absolutely exact his account and the reports of them are. The Chautauqua animal is slightly different from his, but not more so than might be consistent with membership in the same species. In case the Chautauqua animal proves to be distinct, I shall propose for it the name *Platyaspis anodontae*, and for convenience shall so term it in this article.

The facts which are contributed in this paper are derived from studies of preserved material made in the Biological Laboratory of Hamline University. At the time of their discovery I made sketches of the living animals, but did not attempt to study them in detail. Last summer I preserved a few by dropping them into cold saturated aqueous corrosive sublimate solution. The material has its limitations, but is sufficiently well

preserved to enable one, by making total preparations and by serial sectionizing, to recognize all the most important anatomical features of the animal, and, in addition, to see histological detail enough to supplement the anatomical identification of the organs. But I have not been able to demonstrate on the preserved material the exact relation of the different members of the reproductive system, or to follow out the branchings of the excretory system. This, and a more careful study of the histology, I hope to make during the coming summer with the aid of living material. In the meantime I will report the facts as already determined.

I have had only a partial access to the literature of the subject, but gladly acknowledge my especial indebtedness to Monticelli's article in Leukart's Festschrift, in which he gives some account with illustrations of Platyaspis, and to Stafford's article on Aspidogaster. These and other articles referred to are indicated at the conclusion of this paper. I am also much indebted to Dr. W. S. Nickerson of the University of Minnesota, for the privilege of examining his trematode preparations and for friendly advice as to methods of trematode study.

HABITS.

P. anodontae is habitually, if not exclusively, found, not in the pericardial chamber or cavities of the nephridium, but in the mantle chamber, where it is attached either to the surface of the visceral mass, the inner surface of the gill, or to the under surface of the kidney, where the mantle and cloacal chambers communicate anteriorly. While I have not made a sufficiently complete search to be able to assert that it is never located inside of the pericardial chamber or kidney, I feel confident that if it is found there that position is not habitual. This point will receive particular attention in my later work. In its location *P. anodontae* is thus ectoparasitic, and hence decidedly unlike Aspidogaster, which, according to authors, is habitually found inside the pericardial cavity and nephridium. Thus Stafford ('96), p. 8, says: "On opening the Anodonta the parasites are often visible in the transparent pericardium. It

was in this organ that the great mass of Aspidogasters was obtained ; and, generally, they were found closely packed into the anterior corners, at the entrance into the kidney and pericardial gland. In these latter organs I have found a good number, too, but in no other organ have I succeeded in finding any, although I have taken considerable trouble to find evidence of the migration of the young animals." And a similar impression is given by Huxley ('72), Hoyle, *Encyclopaedia Britannica*, XXIII, p. 540, and Monticelli ('92), as well as in most of the current text-books, etc.

Its situation is also quite unlike that attributed by Poirier to *Platyaspis lenoiri*, which is an internal parasite of the turtle. We do not know that Platyaspis does not have two hosts, but the supposition is unlikely in view of the habits of the family Aspidobothridae, and if it should prove to be the fact that it has only one, then these two Platyaspid forms are very different indeed in their host relations.

I am not prepared at present to say much about the host distribution of the parasite, but I can say that in Lake Chautauqua it is chiefly but not absolutely confined to Anodonta. The following Unionidae have been recognized growing in close proximity : *Anodonta plana Lea, Unio luteolus Lam, U. edentula, U. phaseolus Hld., U. gibbosus Brns.*; and while Anodonta seems to be the most usual host, the parasite has been noticed rarely in *U. luteolus*. I have not met with Aspidogaster at Lake Chautauqua, but as it is an endoparasite it may easily be present there and have escaped my notice, since I have not made a point of searching carefully through the pericardium and other organs in which it is reported as likely to occur. I do not, however, imagine that it is very common, for, in case it were, it would surely have attracted attention during the many dissections that have been made by the students.

I have not as yet made a strict study of the habits of the parasite. On opening the mantle cavity of the host in air, one of course subjects the parasite to very unnatural conditions; at such time it adheres to the surface of the host by means of its enormous and highly complex ventral sucker, and its anterior

end is moved in an exploring sort of way. Under compression the anterior end is seen to be very mobile, assuming successively an immense number of apparently random shapes with great rapidity and ease.

External Anatomy.

The individuals externally resemble (see Figs. 1–3) the form represented in Bronn and Monticelli for *P. lenoiri* so exactly that at the outset I was hardly sure that the animals

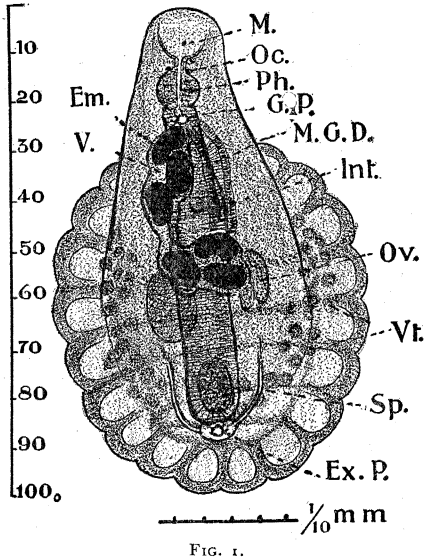

Fig. 1.

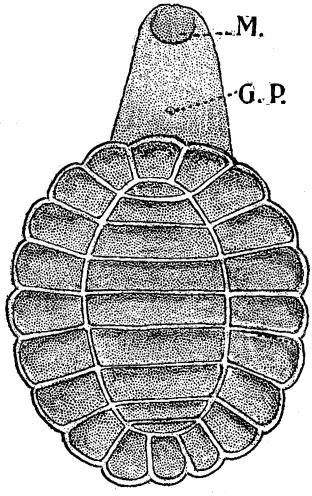

Fig. 2.

Fig. 1.[1] — Camera lucida dorsal view of *P. anodontae* as a transparent object, made from a total preparation in Canada balsam, and by reconstruction from serial sections.

Fig. 2. — Surface view of the ventral surface of *P. anodontae*, drawn with a camera lucida. The genital opening was not seen in the animal, but is introduced from the sections (camera lucida).

are specifically distinct. There is a division of the body into two parts (see Fig. 3), an anterior and dorsal tubular elongate body, resting upon a broad, flat ventral and posterior portion,

[1] The following reference letters are used in all the figures: D., Diaphragm; Em., Embryos; Ex. P., Excretory pore; G. P., Genital pore; Int., Intestine; M., Mouth; M. G. D., Male genital duct; Nv., Nerve trunk; Oc., Eye; Ov., Ovary; P., Parenchyma; Sp., Spermary; V., Vagina; Vt., Vitellaria.

much after the fashion of the relation of a snail's body to its foot. These divisions are maintained internally to a considerable extent, as will be seen later, the alimentary and excretory systems being confined to the body, or "neck," as the dorsal tubular portion is called, while the reproductive system is largely located in the ventral and expanded "foot." The entire length of the animal from the tip of the foot behind to the tip of the neck in front (in an alcoholic specimen) was, in one case, 1.6 mm.; Monticelli gives 1.7 mm. for *P. lenoiri*. The foot, or ventral sucker, is 1.3 mm. long and 1 mm. broad, and is thus the most prominent external feature of the animal.

FIG. 3. — Side view of *P. anodontae*, showing the "neck" rising from the broad foot.

There is no differentiated oral sucker, the wall of the body at the anterior end being thin and delicate and strikingly (see Fig. 4) unlike the much thickened condition found in Distomids, and generally in the trematodes, where a distinct oral sucker is present. The generative opening (Fig. 1, G. P.) is located in the middle ventral line, near the junction of the anterior region with the foot. The hinder broadened portion of the animal consists of a dorsal portion which shades down imperceptibly laterally and posteriorly from the tubular anterior portion and fades out posteriorly to form the broad, flat dorsal surface of the sucker. This latter extends into an extremely thin rim all around the edge of the foot, and includes a flap which extends in front of the junction of the sucker with the anterior region of the body. On the hinder dorsal surface of the body, near the extreme posterior end, is located the opening of the excretory system (Fig. 1, Ex. P.).

The ventral sucker itself is subdivided, the plan of its subdivisions being entirely unlike that of Aspidogaster, and as distinctly similar to that of Platyaspis. The surface of the sucker (see Fig. 2) is regularly subdivided by transverse and longitudinal folds into compartments, of which there is a distinct peripheral series of 20 compartments and a median series of 9, making 29 compartments in all. The precise position of the

ridges which border these compartments is shown in the camera lucida drawing of the ventral surface. This number of compartments is different from that given by authors for *P. lenoiri*, where there are 25 compartments, 18 in the peripheral series, and only 7 in the median row, in place of 20 in the peripheral and 9 in the median row, as here. I have, however, not determined how constant the plan of this subdivision of the ventral sucker is, but I have found the number given in my figure in about twenty cases.

Internal Anatomy.

The animal is covered with the usual trematode body wall, consisting of a thin and delicate cuticle, beneath which, in sections, the ends of muscle fibers are recognizable. Internally

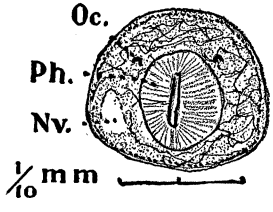

Fig. 4.

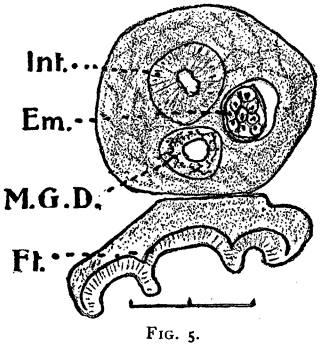

Fig. 5.

Fig. 4. — Transverse section, passing through the eyes, level Oc. in Fig. 1, No. 12 of series (camera lucida).

Fig. 5. — Transverse section, No. 31 of series. The left of the section is the right side of the animal (camera lucida).

the inter-spaces between the organs are filled in with the usual parenchymatous tissue. This is subdivided into that of the body and that of the foot by a transverse diaphragm, as seen in Fig. 6. The alimentary and excretory systems lie wholly dorsal to this structure, as well as the terminal ducts of the reproductive system, while the gonads themselves, and the vitellaria, are wholly ventral to the diaphragm.

The alimentary system begins with a widely dilatable funnel-shaped "pre-pharynx," surrounded by the extremely mobile and

thin-walled homologue of the oral sucker. This narrows rapidly posteriorly and leads into a pharynx, oval in outline, and composed of muscular tissue and cuticularized on its outer surface. Posterior to this chamber there is, as in Aspidogaster (Stafford, Fig. 1) and Stichocotyle, Nickerson ('94), a very short oesophagus, whose wall is cuticularized and not glandular, followed immediately by a single, rather large tube, the intestine. This runs down the body to near the posterior end (section No. 88 of Fig. 1), where it ends on the same level as the opening of the

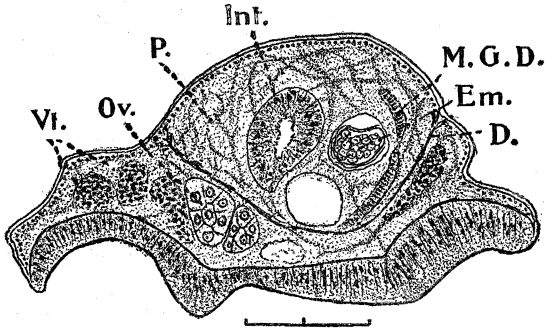

FIG. 6. — Transverse section of *P. anodontae*, serial No. 54, passing through the ovary. The right side of the figure is the left of the animal (camera lucida).

excretory system. This tube has a uniform diameter (see Int., Figs. 5, 6), and is lined with tall glandular cells, which are, many of them, peculiarly vacuolated at the outer end (*i.e.*, next the surface of the membrane), as noted by Nickerson in Stichocotyle.

The excretory system was only recognized in sections, and, as to its terminal portions, its minor divisions, and their relations to the inter-spaces of the parenchyma, must be studied upon living specimens. The excretory pore is clearly visible in sections and in surface views of total preparations. It is located in section No. 83, and it is a single opening, and not double, as reported for Aspidogaster by Stafford. The sections on which this conclusion rests are not shown in this article, but will be given in connection with my later paper. Two enlarged terminal collecting excretory vesicles are seen meeting beneath the surface pore in horizontal sections. They can be traced forwards on either side, but ultimately they are lost in the parenchyma. These points are indicated in Fig. 1.

The nervous system was only imperfectly seen. I did not recognize it at all in the living animals, and it barely shows in the total preparations, but in transverse sections it is clear that there is a large band of fibers crossing the pharynx dorsally—far forward (in section No. 10), and extending down ventrally around the pharynx so as to more than half encircle it. A lateral nerve can be traced posteriorly in a few sections. It shows at Nv. in Fig. 4.

Just posterior to this nerve band there are located two symmetrically disposed organs. They are shown at Oc. in Figs. 1 and 4, where their location is indicated. They are, apparently, invariable structures, very noticeable in living animals, and I have found them in every individual that I have examined without any exception. They are spherical bodies located in the parenchyma, deeply below the surface and near the anterior boundary of the pharynx ; they are posterior and close to the cerebral nerve mass. They are spherical and apparently hollow. The surface is pigmented ; the pigment, in the form of minute grains, is clearly visible under the immersion lens ; these grains are, apparently, scattered on all parts of the surface of the sphere, but they are much more closely deposited on the inner and upper side. I have not thus far recognized any lens. I have from the first considered them eyes ; their invariable presence, their position in the neighborhood of the cerebral nerve mass, and the presence of pigment demanding this identification. If, however, we accept them as eyes, we must recognize that *P. anodontae* differs in possessing them from adult trematodes generally. It is well known that eyes are present in early stages of the trematodes, but they are not hitherto recorded of adults, so far as I am able to learn. The accounts of *P. lenoiri* do not mention this point, and the illustrations do not shed any light on the question ; so far as can be ascertained from them, these organs are wanting in the African form. There is no room for doubt as to the Chautauqua animals being adult; the condition of the reproductive system at large and the presence of eggs and embryos settle that. It is, perhaps, hardly worth while to speculate on the matter now, but I cannot help noting the possible correlation between

the comparatively free life of *P. anodontae* and the possession of eyes, in contrast with the absence of eyes in the strictly endoparasitic *P. lenoiri* and its allies, the other genera of this family.

The location of the chief organs of the reproductive system agrees closely with that indicated for *P. lenoiri* in the figure in Bronn (Pl. XX, Fig. 1); and it is also very similar to the arrangements found in Aspidogaster. I have not been able to trace all of the windings of the ducts by the section method; their intricacy has made it impossible to do so; but I feel reasonably sure of the identification of the portions which I have introduced into the partially diagrammatic Fig. 1. The spermary is single. It is recognized by the presence of small spermatic cells, but no spermatozoa were recognized in any of the sections. The organ is oval, large, and located about on a level with the hind end of the intestine, and ventrally to it. The nuclear material indicated, possibly, some activity in the tissue, but no mitotic figures were visible. I have thought of two suppositions by which to account for their absence, *viz.*, the organs may not have been in a state of activity at the time; and, second, the methods of preservation may not have been adequate. I found in staining that the presence of the cuticle interfered with the action of reagents, and it is quite possible that the germinal cells, if active, got into a state of rest before the reagent used in fixation had had time to take effect. The almost invariable presence of the embryos in the vagina seems to indicate that the animal is mature and that, consequently, these organs are or have been active.

There is a single ovary. It lies on the right side of the body (see Figs. 1 and 6), near the middle, and ventrally to the intestine, and below the diaphragm. The vitellaria are also conspicuous, lying scattered through the ventral portion of the flattened body, near its margin. I have not as yet succeeded in tracing the ducts which connect the different portions of the female reproductive organs. The terminal portions of the reproductive system have been identified with reasonable certainty. The generative opening is visible in the mid-ventral line of section No. 23. This places it in front of the foot, in

the position indicated in Fig. 2, the same position as that assigned to it in *P. lenoiri*, in Aspidogaster, and in Stichocotyle. Two distinct passages lead posteriorly from this common opening, the male and the female ducts. These have not been followed back so as to enable me to base their identification upon a connection, respectively, with the spermary and ovary. However, I feel tolerably sure that the one on the right side is the male passage and that on the left the female, as indicated in Fig. 1. The latter contains a small number of oval chitin-enclosed capsules, usually about six, which I am inclined to regard as embryos. They are conspicuous in total preparations, and in sections the chitinous capsule is seen surrounding a mass of protoplasmic nucleated cells. These objects are, apparently, identical with similar structures located in the passage leading to the uterus in Poirier's figure (Pl. XX, Fig. 1). According to that figure the passage is one which leads directly from the ovary, and receives a duct from the yolk gland and vitellaria in its course. The objects in the duct are very different indeed from the embryos of most flukes, including the innumerable small embryos of the closely allied Aspidogaster ; but their situation and their chitinous covering are so identical with those of the fluke embryos at large that there can be no doubt that these are embryos, but extremely interesting from their unusual size. It is obvious that in Platyaspis we have to do, not with an immense number of small embryos, as in the flukes generally, but with a few large ones.

If we accept the view that these objects are embryos, we are then able to identify the passage containing them as the vagina, an identification which locates that organ as it is located in *P. lenoiri* and Aspidogaster, but not in Stichocotyle, where it is on the right side (Nickerson, '94, p. 477). I might add that it is some additional evidence in favor of this identification that the wall of the organ agrees histologically with that of the homologous organ of Aspidogaster.

The other of the two passages opening at the genital pore is thus indicated to be the cirrus organ, the terminal portion of the spermiduct. In favor of this view, in addition to the points mentioned in connection with the identification of the other as

the oviduct, is its histological structure, which closely resembles that indicated by Stafford for Aspidogaster.

SYSTEMATIC POSITION.

The question of the systematic position of the Chautauqua Platyaspis does not at present admit of a final answer. There can be no doubt of its generic position. Its anatomy agrees so completely with *P. lenoiri* in all essential particulars, and is so completely unlike that of the other genera of the Aspidobothridae in all generic points, that it can, I think, be finally stated that it is a species of Platyaspis.

The only divergences thus far recognized from Poirier's species *P. lenoiri* are in the number of the compartments of the ventral sucker and in the presence of eyes. As for the first of these, it would be necessary to study the case of the American species more fully to determine whether the number of compartments is a constant feature; so far as is at present known it is constant. And it would be necessary to study the African species as well, to determine whether the account of Poirier is to be regarded as absolutely and exactly true and invariable. If such should prove to be the case, it would furnish good grounds for regarding the American form as specifically distinct. As for the point about the presence of the eyes in one case and their absence in the other, it is possible that the organs are not functional eyes, but only rudiments, which are more distinct in the American form than in the African. They may be present in the African form, but less distinct, and so may have escaped notice. At all events, it is at present impossible to decide that the animals are specifically distinct. Still, since they are so widely apart in home and habit, at least so far as our present knowledge of them goes, it appears, on the whole, best to recognize them by distinct names.

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BIOLOGICAL LABORATORY OF HAMLINE UNIVERSITY,

March 22, 1898.